

## Introduction to the AFTA report

Subject: What you can do with a wide-field, high resolution space telescope the size of Hubble?

Audience: John Grunsfeld, OMB, Congressional staffer, Charlie Bolden, astronomy “fan” (?)...

# AFTA – wide-eyed daughter of the Hubble Space Telescope



## Goal #1: Deep Space Wallpaper

A. The AFTA Degree Deep Fields – 2 x 2 mosaic  
(of the 8x3 chip format) 4 spaced around the sky

These pictures will be “wide screen”, 2.4:1  
64k x 24k pixels

At 200 pixels per inch, they will cover 27' x 10' wall  
(8-m x 3-m)

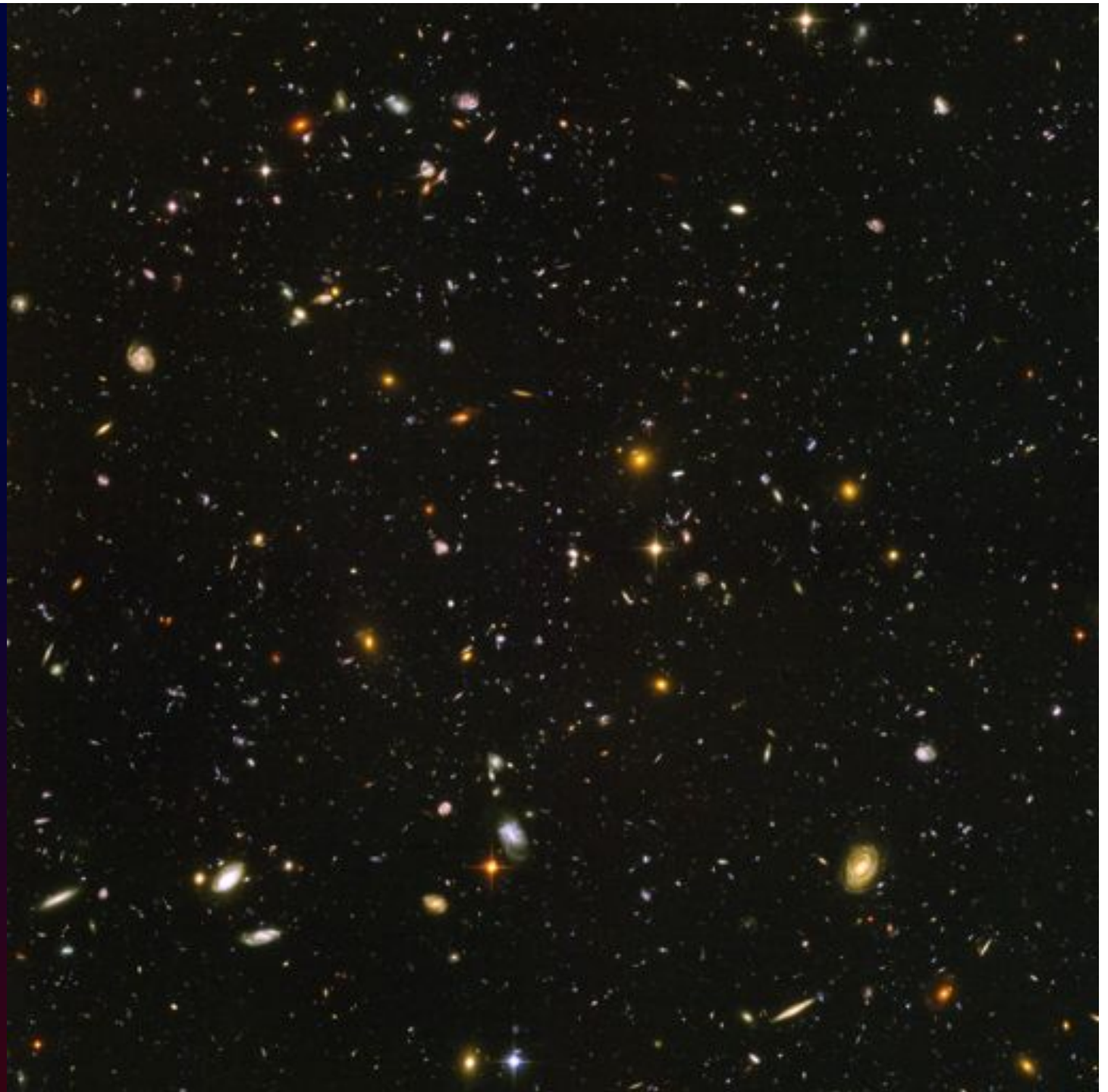
Murals: These 4 pictures will enclose an open space  
at the Smithsonian Air & Space Museum

NASA will send to any K-12 student a room-sized  
version, 13' x 5', in (2) 30" wide 13' long rolls, i.e.  
WALLPAPER<sup>a</sup>

<sup>a</sup> Or maybe, in 2022, kids just have to download to  
their wall. -- saves on printing and postage.

## Hubble Ultra Deep Field

205 arcsec sq  
→ 9" square  
on the 27-foot  
wall

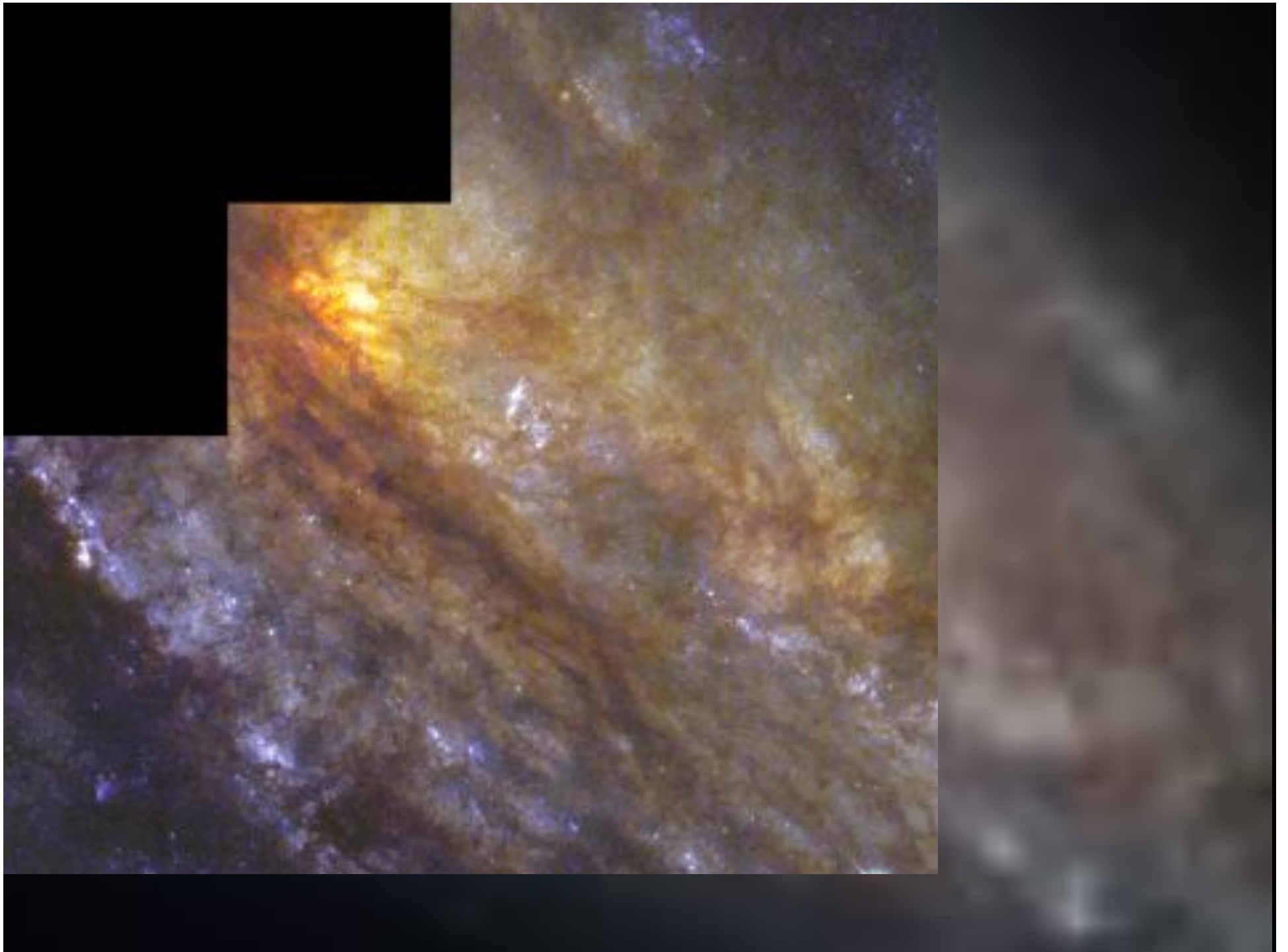


## 2. Goal #2 Space Neighbors wallpaper

Picture of a big galaxies 2 x 2 mosaic (1 sq deg)

Picture of the moon 1 x 2 mosaic – 500 ft resolution (ND=2!)

Picture of Mars at comparable resolution? (from Mars mission)





Goal #3: A sample of a *Guest Observer* program as rich (twiddle) as Hubble's , requiring a wide, wide field in the near-IR

*Not just a billion little dots!*

*Big structures* on the sky, for example:

Star formation and star clusters in the Milky Way

Neighboring Galaxies

generations of star formation  
building galaxies

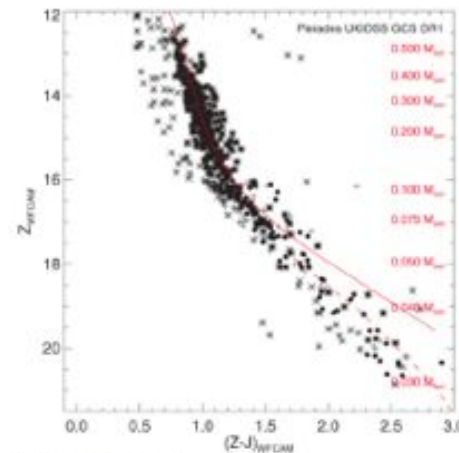
Galaxy clusters

Large-scale structure at  $z \sim 7$

George Rieke (UA), [grieke@as.arizona.edu](mailto:grieke@as.arizona.edu) and John Stauffer (IPAC), [stauffer@ipac.caltech.edu](mailto:stauffer@ipac.caltech.edu)  
**Extending Open Cluster and Star Forming Region IMFs to the Planetary Mass Regime**

George Rieke (UA), [grieke@as.arizona.edu](mailto:grieke@as.arizona.edu) and John Stauffer (IPAC), [stauffer@ipac.caltech.edu](mailto:stauffer@ipac.caltech.edu)  
**Extending Open Cluster and Star Forming Region IMFs to the Planetary Mass Regime**

Star forming regions: Taurus, Sco-Cen,... "much lower" (!)



Color-magnitude  
diagram for proper-  
motion-selected stars  
of the Pleiades  
(UKIDSS, Lodieu et al.  
2012 MNRAS)

Depth – To below 10 M(Jup) at  $r \sim 175$  pc – i.e. to  $K \sim 23$  (5 sigma)

Field of View – Full cluster extent, regions of order 25-50 square degrees per cluster

Cadence – J and K band; two to three epochs (at least at K) separated by 3 or more years

**Wavelength Coverage – Two NIR filters for color-magnitude diagram analysis**



## WFIRST Guest Investigator (GI) and General Observer (GO) Science Cases

Jason Kalirai (STScI), [jkalirai@stsci.edu](mailto:jkalirai@stsci.edu)

### The Infrared Color-Magnitude Relation



a major step forward in the chronology of our Galaxy

#### Key Requirements

Depth – Well dithered exposures extending down to the H burning limit in clusters with  $[Fe/H] = -2.2$  to  $0.0$  (i.e., 10 kpc)

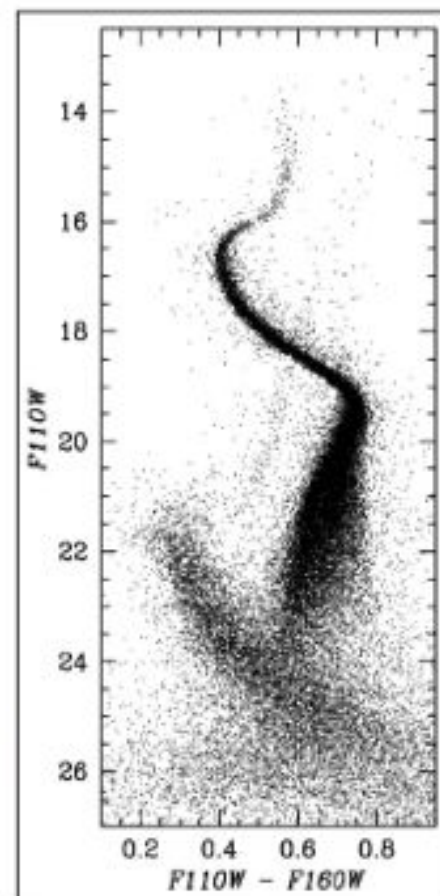
Field of View #1 – Single pointings for globular clusters covering appreciable spatial extent

Field of View #2 – Wide field survey of Galactic plane sampling over star forming regions and spiral arms

Cadence – One image per galaxy

Wavelength Coverage – Two NIR filters for color-magnitude diagram analysis

Caption: IR color-magnitude diagram for the nearby globular cluster 47 Tuc, constructed from a 3 orbit (depth) observation with HST/WFC3/IR (Kalirai et al. 2012). The kink in the lower main-sequence of the cluster is caused by  $H_2$  opacity. The fainter main-sequence represents stars from the background SMC galaxy.

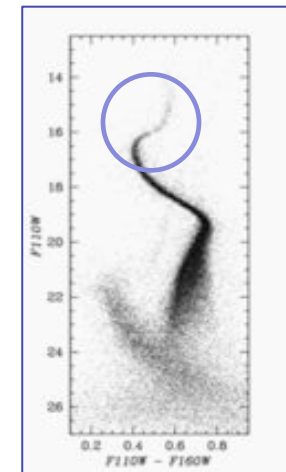
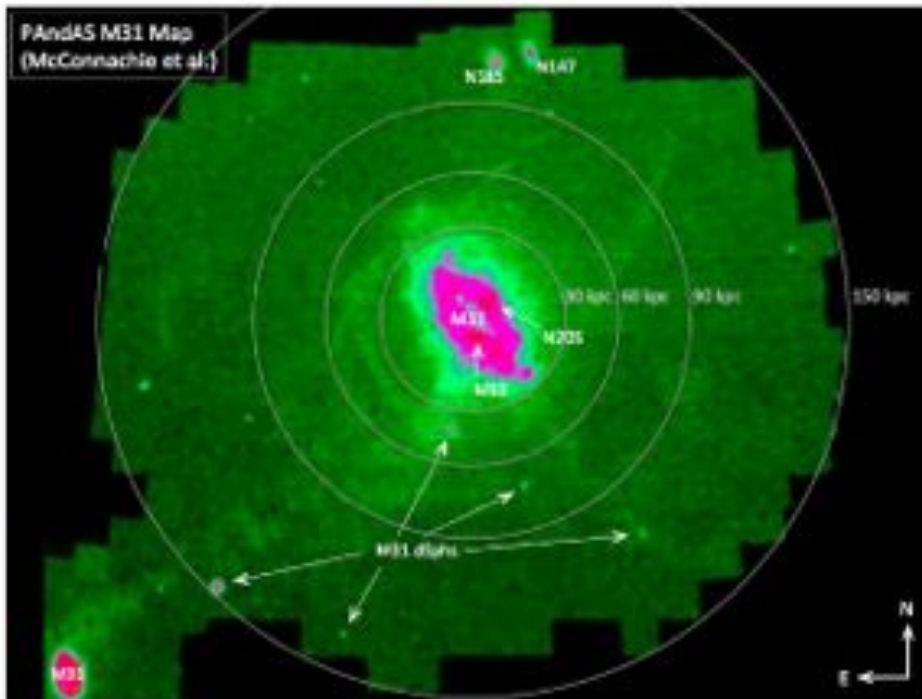


## WFIRST Guest Investigator (GI) and General Observer (GO) Science Cases

Roeland van der Marel and Jason Kalirai (STScI), [marel@stsci.edu](mailto:marel@stsci.edu); [jkalirai@stsci.edu](mailto:jkalirai@stsci.edu)

### Dissecting Nearby Galaxies

With AFTA, huge and deep images ~100 nearby galaxies (3 mag RGB)



Caption: A (very) wide-field map of M31 from the PAndAS survey (McConnachie et al. 2009) reveals the clearest picture of substructure in a spiral galaxy's halo.

#### Key Requirements

Depth – Several magnitudes of the red giant branch in ~100 galaxies (i.e., out to  $d = 5$  Mpc)

Field of View – Full halo extent out to 150 kpc (tiling in nearby galaxies)

Cadence – One image per galaxy

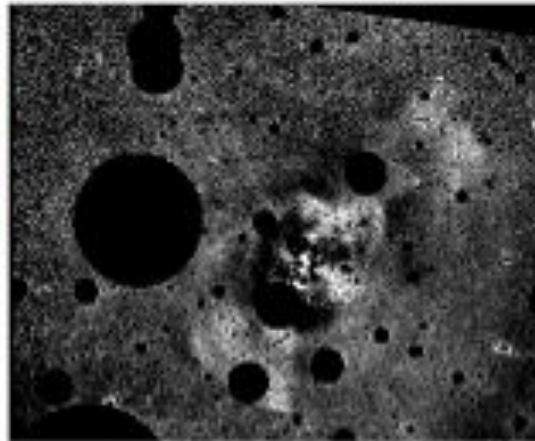
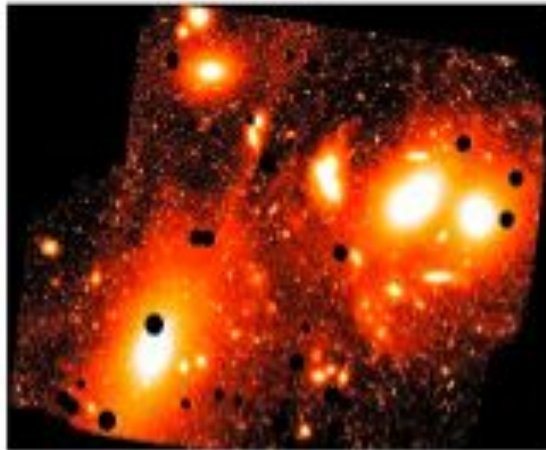
Wavelength Coverage – Two NIR filters for color-magnitude diagram analysis



## *WFIRST Guest Investigator (GI) and General Observer (GO) Science Cases*

Chris Mihos and Paul Harding (Case Western), [mihos@case.edu](mailto:mihos@case.edu); [paul.harding@case.edu](mailto:paul.harding@case.edu)

### **Deep Surface Photometry of Galaxies and Galaxy Clusters**



Left — Deep imaging of diffuse ICL in the Virgo Cluster (Mihos et al 2005), showing tidal streams and extended galaxy halos. The image covers  $2.5 \text{ deg}^2$  to a limiting depth of  $\mu_V = 28.5$ .

Right — The Virgo elliptical galaxy M49, after subtraction of smooth light profile, showing a complex system of diffuse tidal shells from a recent accretion event (Janowiecki et al 2010).

#### **Key Requirements**

Depth — Limiting J-band surface brightness of  $\sim 27 \text{ mag/arcsec}^2$  ( $\sim 0.001 \text{ MJy/sr}$ ).

FOV — Wide field necessary to cover nearby galaxies and galaxy clusters with a minimum of tiling.

Low scattered light — Off-axis design and pupil mask would limit contamination from stray light.

PSF stability — PSF stability on large scales necessary for proper subtraction of stellar wings.

Wavelength — IR needed to sample peak of old population SED, better trace stellar mass distribution, and minimize contamination due to scattering and absorption from Galactic and target galaxy dust

# From Marc Postman's contribution to the New WFIRST Whitepaper

## Deep cluster images to find the most distant galaxies ( $6 < z < 15$ ) from strong lensing

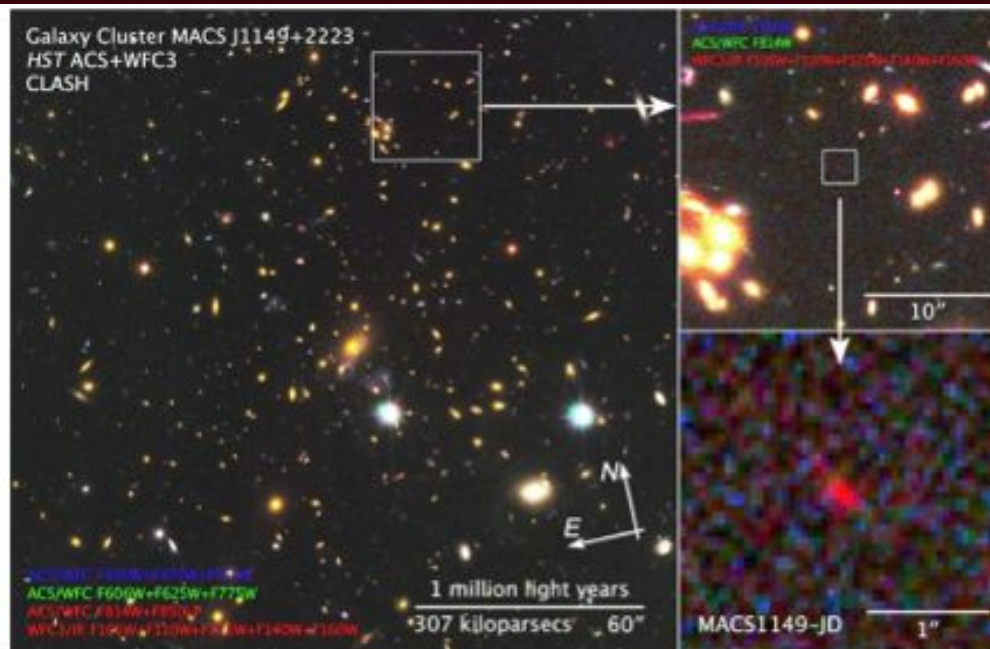


Figure 14: A candidate for a galaxy at  $z = 9.6$ , magnified by a factor of  $\sim 15$  by the foreground cluster MACS J1149+2223 ( $z = 0.54$ ). The object was found in an HST survey using the WFC3IR camera (Zheng et al. 2012). This young object is seen when the universe is only  $\sim 500$  million years old.

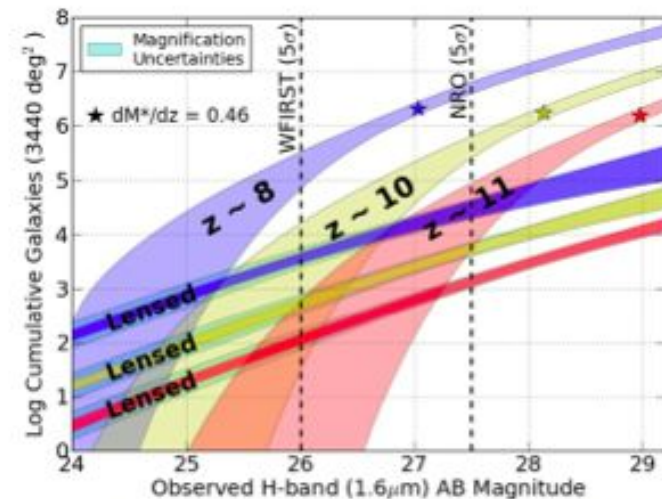


Figure 15: The cumulative number of lensed and unlensed  $z = 8, 10$ , and  $11$  galaxies predicted in the NEW WFIRST HLS. Darker curves correspond to the lensed number counts. Lensing is advantageous primarily for finding bright ( $H < 25.5$  AB mag)  $z > 9$  sources. The unlensed field will produce an overall higher number of  $z > 8$  sources, however.



## WFIRST Guest Investigator (GI) and General Observer (GO) Science Cases

Megan Donahue (Michigan State University), [donahue@pa.msu.edu](mailto:donahue@pa.msu.edu)

### The Evolution of Massive Galaxies: the Formation and Morphologies of Red Sequence Galaxies

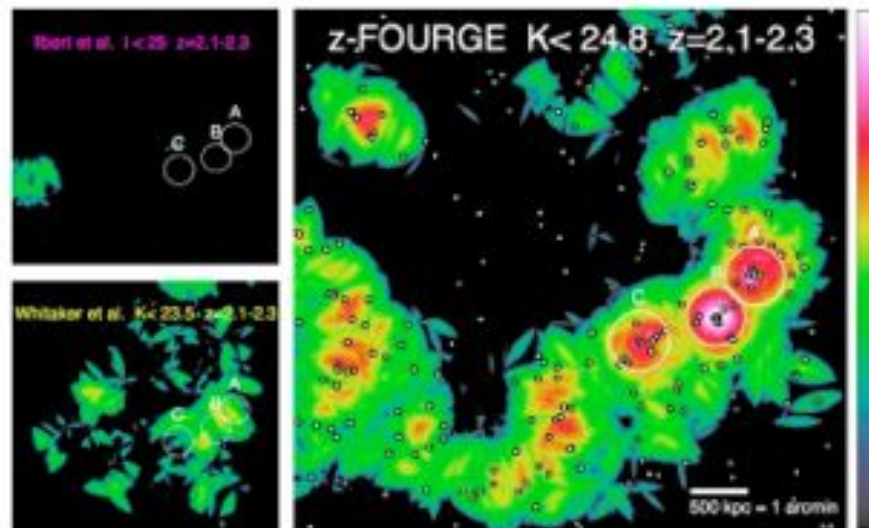
#### Key Requirements

Depth – Well dithered exposures sensitive to  $K \sim 25-26$  (AB)

Field of View – Targeted follow-up of high- $z$  candidates (from Sunyaev-Zeldovich surveys or other techniques). Cluster size is  $\sim 1-2$  arcmin,  $\sim$  independent of  $z$ .

Field of View – Survey for  $z=1.5-2.5$  clusters:  $\sim 100$  sq degrees would include  $\sim 20$  clusters at  $M \sim 10^{14} h^{-1}$  solar masses if you had to find the clusters first.

Wavelength Coverage – Medium-band NIR filters.

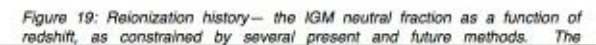
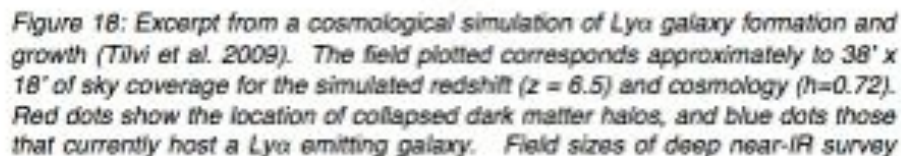


Caption: Nearest-neighbor surface density maps for  $z = 2.1-2.3$  in a  $9' \times 9'$  region in the COSMOS field (Spitzer et al. 2012).



## Large-scale structure during the epoch of reionization (age of universe < 1 billion year)

-- prediction is for ~1000 LAEs per sq deg at  $z=8.5$



## Goal 4: Exoplanets: Microlensing

Discover the architecture of planetary systems where most planets are born -- beyond the snow line. Complete what Kepler started, and get the best estimate of the size-distributions of planets, from jumbo Jupiters to mini-earths.

## Exoplanets - Coronagraphy

Develop and test technology for future earth-finders, measure exo-zodis, image Jupiter analogs found by radial velocities, and --- if we lucky - find an earth-like world within a few parsecs

Goal 5: Probe the greatest mystery of the age --  
"dark energy"

Measure the acceleration of the universe to  
unprecedented accuracy - try to learn what it is,  
and what it tells us about the past and the future.

Dark energy surveys provide the biggest bonanza  
in galaxy evolution studies of all time.

fin

